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INTRODUCTION

DISCOVERIES CLAIMED

1. The one only kind of matter and its definition.
2. Motion of matter the only active causation.
3. Organization the mode of existence upon which all higher order of bodies and forces depend.
4. The *atom* its form and system of organization.
5. Differentiation of velocities the great, the pre-eminent, cause process in the universe.
6. The causation of radiation and gravitation.
7. The great primary double development process concentration of matter and dispersion of energy.
8. The second great evolution process rotation and its important agency in atomic development.
9. The mode by which atoms combine and interact chemically.
10. Molecular structure the atomic arrangement.
11. The true nature of chemical attraction, repulsion, affinity, valency, stability, etc.

While it is claimed that our system accounts for all the facts of physical nature the author relies especially for demonstration upon its explanation of chemical facts. Chemistry deals with the relation of atoms to each other, and, since atoms are definite, specialized bodies and systems, the modes of their mutual relation and force conditions may be traced out to a definite conclusion. It is the intention to follow this essay with a special treatise on chemistry in its relation to our system. The very oblate spheroidical atom, with its bipolar affinities and combination by polarities will be presented as the key note of the system. Upon this basis for chemistry we will challenge the analysis and criticism of chemists.

1. PROPOSITION.—Distributed throughout universal space exist bodies of absolutely simple, perfect fluid matter: these bodies and their motions in relation to each other constitute the physical universe. Distribution is uniform when considered universally, but local process of condensation form larger bodies and regions of greater density. There exist three great distinct orders of bodies: the primary order, the atoms, and the stars. The stars also are subject to the great law of concentration as evidenced by the galaxy, but our discussion will not exceed the limit of the star order.

Orders of forces are also developed at the same time that orders of bodies are formed. Atoms are not only bodies, they are *systems,* and have mechanisms of attraction and repulsion.

The stars also are systems and have their mechanism of gravitation and radiation. The processes which cause the attraction of atoms and the power of gravitation are strictly analagous and exceedingly simple. Radiation, the outflow of energy from a center, is but one part of a great double process. Its coordinate part is the inflow of matter to the same center and the latter is the cause of attraction. Star systems rotate and we will show that atoms also rotate. The same cause process operates in both cases and is of the utmost simplicity. Rotation is a very important process in the systems of both the atoms and the star, since upon its action depends in large measure the course of development, the *kind* of universe which actually exists. The potency of the rotary process is eminently exampled in our solar system and we propose that it is equally important to the mechanism of the atom. The *nebular hypothesis* of Laplace gives a worthy account of solar development but it omits the greatest order of matter and motions, that is, the primary order and therefore falls short and fails to explain the double cause process by which gravitation and radiation develop and exist.

The primary order of matter and motions is the greatest physical fact in the universe and since we propose that it is the final basic order we begin with it the development of our system.

2. SPACE AND MATTER.—Space is the pure, absolutely simple principal of expanse.

Bodies may exist in space, may occupy and move through it, but space has no potency or function but to contain. This is no departure from the Newtonian standpoint. Bodies of matter have no existence potential or otherwise outside apart from their own substance. Space not occupied by substance is absolutely void. Action at a distance is an intellectual myth. All active causation has for its mode of existence the motion of matter bodies. Bodies can only act upon each other by moving against each other with the consequent pressure. *Push,* not *pull,* is the mode of all cause action.

Matter therefore is the one great physical element. Motion, the basis of energy, is but the positional change of bodies of matter, and these changes are but relative as between different bodies, that is, motion is relative, not absolute. The first order of matter consists of simple masses, and the other two great orders are built up by constructive development. The primary order is absolutely simple, while the character of all higher orders of bodies and also of forces depends upon the great principle of *organization.* Organization is of such preeminent importance that it may be said to be the characteristic mode of existence of all higher forms. The first simplest process of development proceeds by the organization of motions to and from a center, regular inflow and regular radiation. Matter exists in and occupies space, hence it must have a quantity relation to space. We assume that the plenum, although a complete universe, would be incapable of development so as to coincide with actual existence. Hence we adopt the alternative that the quantity of matter existing is not sufficient to fill all space, but part is left void. The exact ratio which the quantity of matter, or the space occupied by it, bears to the part left void cannot of course be predicted, nor is it necessary, because the kind and mode of development is not dependent thereupon.

The quantity relation between matter and space is a vastly important condition because upon it depends all differences of density. Such diversities of density as actually exist are inconsistent with the reality of a plenum.

3. THE PRIMARY ORDER OF MATTER AND MOTIONS. —Only one kind of matter exists, and the primary order of matter is its actual representative in its simple final elementary state.

The minute masses which constitute the primary order of matter have no regular form, but take all the diverse shapes which result from countless and constantly recurring collisions and the divisions of mass which result. The masses are perfect fluid and absolutely simple, hence have no tendency to any shape nor do they offer any resistance to division, but their mutual action and reaction have only inertia to overcome. The motions are equally simple, being the opposing motions which motions in all directions signify. This state of motions make frequency of collisions inevitable.

The primary order of matter and motions is the simplest as well as the greatest order of physical existence. Atoms and stars are but as waves, which rise, fulfill their time, and fall back into the great and simple order from which they derive their origin and owe each moment of their existence. The primary order, the simple masses and motions, and these *only* of all physical being, exist changeless from the infinite to the infinite. Division of the masses and differentiation of motions, caused by the action and reaction of collisions, go on always but these are not changes in the simple state of the masses and motions which constitute the basic order of physical existence. Differentiation of motions causes actual change of state only when an original *variation* becomes the beginning of an *atom.*

4. VARIATION.—This is a positive condition in the universe and not a mere chance. The primary masses move in every direction and such motions constantly tend to concur, that is, a greater number of masses than the *average* tend to come together in time and space and form regions of greater density. These *variations* all tend to be starting points of regular development, that is, of radiation and radial inflow.

Variations are, however, different in degree and the greater are the more likely of course to survive their environment, absorb those of less degree and become the centers of actual atomic evolution. It is a case of contest between many and survival of the greatest rather than of chance.

Variation is a principle of great importance because it initiates all cases of development and all changes in the character of development from the simplest to the most complex kinds of organization.

5. THE FIRST DEVELOPMENT PROCESS.—When two masses of primary matter meet in collision their inertia causes them to act by pressure against each other. The motions of reaction represent of course the same amount of energy as the original motions. The reacting motions are really a new set of motions, the product of the pressure, which the impacting masses exert against each other. The new motions move outward along the plane which passes through the center of collision, at right angles to the line of original meeting. It is quite evident that the parts of the masses which are nearest the plane of meeting will be subjected to the greatest pressure, hence the new motions nearest the plane will acquire the greatest velocity and energy of motion.

But since the total of energy contained in the motions is the same throughout all changes, therefore the swifter motions carry away from the center of collision a greater quantity of energy than the same matter in the original motions brought to that center. Wherefore these greater velocities denote a dispersion of motion energy, and, of course the slower motions of the remaining matter signify a concentration of matter. In other words, the result of the process represents simply loss and gain of energy between different parts of the colliding masses.

This simple process of action and reaction between different masses of matter impacting upon each other, is the great, the only truly great, cause in nature. All others are relatively insignificant. We call this process the differentiation of velocities and the primary or first process. It is chief in all the evolutions and force activities of the universe. Upon its power depends not only the origin of all systems, all organizations, but also the continuance of their existence. Its first work is the forming of atoms, its second the building of suns. It is the direct cause of the great systems of radial motion to and from central bodies which the terms *radiation* and *attraction* are used to represent. This radial motion is the simplest, and in rank the first kind of organization in nature. The attractive and repulsive forces belonging to atoms denote its first and simplest manifestation. Atoms are immense bodies compared to the minute masses of the primary order of matter. These minute masses impact upon the atomic bodies and the reacting motions being differentiated, the swifter fly off from the atom and are the cause of repulsion, while the parts of the masses which lose their motion are added to the atomic body. This process of condensation necessitates the inflow which is the cause of attraction.

6. THE ATOM.—When several collisions between primary masses concur or come together, the variation thus produced will, if it happen to be of a sufficiently high degree, be the origin of an atom. The first process differentiation of velocities, *always* tends to cause a region of greater density to increase in density. Greater density causes a greater frequency of collisions, and a greater frequency of collisions causes increase of density. This

progressive process is the builder of atom, star and galaxy.

The first development process acting alone would construct a *globular* atom, because the inflow and addition of matter would be about equal from all directions, but another process, the second development process, *rotary motion* interevenes.

Rotary motion starts from an original *variation* in the equilibrium conditions of the forming atom. Rotation is also a progressive process. The impacts of radial inflow are carried over the center in the direction of rotary motion, and thus part of their energy is used in promoting rotation. The atomic body being perfect fluid matter, and absolutely simple and free with reference to force conditions, it therefore offers no resistance, save inertia, to the change of form to which rotation tends. Nor does the radial inflow offer any such resistance, hence the atom bulges at the equator without restraint, until it becomes so flattened and the equator so thin that the impacts of the primary masses upon it, together with the influence of the centrifugal force, detach matter from the equator equal in quantity to that added to the atom by accretion. The atom then ceases to grow, has a fixed magnitude. The matter added to the atom must acquire rotary motion before it can produce the *effect* of rotation, hence this is a governing check upon the development of rotary motion. The atom therefore is a fixed, stable system in mass and mechanism. It is a very simple system and examples the first order of organization, the first step up from the great, the simple basic order of existence. Atoms have been evolved in immense numbers in the vast reaches of space, and by numerous local concentering processes have formed another, a higher order of bodies systems, the stars.

7. THE BUILDING OF A STAR.—A *variation* is the beginning of a star just as it is of an atom. The significant difference lies in the fact that, whereas atoms are formed by the *coalescence* of simple masses into one

greater mass, stars are formed by the collecting together of a vast number of distinct unit systems, that is, atoms, into a great assemblage. The fact that the material of which a star is made consists of distinct units instead of simple masses, has a very important influence upon the course and character of development. The process differentiation of velocities is the cause of concentration, whether of atom, star or galaxy. The whole process is of the utmost simplicity and so gradual as to consume an enormous period of duration. The double radial process, the inflow of the minute primary particles to the forming sun or star, and the outflow of energy by means of the swifter motions which are the product of differentiation, develops gradually in power as atom after atom is added to the growing body or *nebula* in the earlier stages. A variation begins rotation, perfect non-rotary equilibrium being impossible. As in case of the atom rotary motion develops progressively, because the motions of the radial inflow are turned in the direction of rotation, and expend part of their energy upon its increase.

The outcome of the rotary process is far different in the two cases, that of the atom and of the star. This is because the atom consists of simple matter, whereas the star is composed of distinct unit systems having attractive mechanisms of their own. Thus while the atomic body does not resist change of shape as the effect of rotation, the nebula does resist a deviation from the globular form. Any amount of rotary motion, even the least, will cause the atom's equator to extend and become so thin that it is not able to withstand the blows of the primary masses upon it, but the rotation of a nebula must develop to a rather high degree in order to produce the effect that is evidenced in our own solar system. The matter detached from the atom's equator consists of simple perfect fluid masses, which being subject to a mutiplicity of collisions from the masses of the primary order soon lose their identity by division. But the matter detached from the nebula by rotary motion consists of atoms which retain their identity, and moreover, are still subject to the centripetal action of the radial inflow of primary particles which is the operative cause of gravitation. This force, therefore binds the equatorial ring to the system and in course of time, if a sufficient degree of variation exists, the atoms of the ring concentrate around to one place and form a secondary nebula which may undergo a process of evolution like that of the parent nebula. All the processes are exceedingly simple from our standpoint. The rotary process is very important although it follows and depends upon the primary development process. The latter's representatives in the solar system as it exists at present are gravitation and radiation.

The development of these organized motions is gradual and continuous from the first and still goes on. Atoms are being and have been added as they come from the depths of surrounding space. Each atom brings to the great sum of attractive power its mite of attraction. Without the rotary power, or if the development of rotation were insufficient to form the rings whose atoms have concentered into their respective planetary systems, the solar system would consist of one great central globular body. This would be as truly a star or sun although its system would be far simpler than it actually is. Among the starry hosts existing in the deeps of space different degrees of variation, with reference to rotation, are doubtless exampled just as is the case in the development of atoms.

II. CHEMISTRY

1. Atoms and Molecules.—An atom is a body of matter, but it is also the seat of force activity, the center of organized motions. The form of the atom is that of the very oblate spheroid. Attraction and repulsion are the forces which belong to an atom. The primary order

of matter and motions which surrounds the atom, or in the midst of which the atom exists, is the operative cause of attraction and repulsion, the atom being simply a relatively vast body upon whose surface the minute primary masses impact with great frequency and multiplicity. It is plain that the differentiation of velocities which take place upon the surface of the atom are very much intensified. Each pole is the center of this great activity for its own side, for the atom may be said to have two sides since it is so very oblate a spheroid. The flatness of the atom may be judged from the condition that its equator is so thin that the minute primary masses detach matter therefrom by the blows of their collisions.

The equatorial zone is however *narrow*, because the masses lost to the atom at the equator are very much larger than the minute particles whose intense collision velocities dislodge them. The two circular zones situate inside of the equatorial zone, one upon each side of the atom, are zones of absorption where matter derived from the impacting masses is added to the body of the atom, hence these circular areas are zones of attraction, while the equatorial zone is one of repulsion. The inflow which constitutes the attractive mechanism of the atom is directed to all parts of the zone upon either side where matter is absorbed, hence attraction is not directed as to the center of its attraction zone. Repulsion is caused by the swifter motions which escape and disperse, from the intense differentiation that takes place upon the surface of the atom. The equatorial zone of loss has no attraction, but the motions which cause *repulsion* proceed from every part of the atom's surface. The basis of both the attraction and repulsion processes consists of the impacts of the primary masses upon the atom, but there is another condition which makes repulsion greatest at the pole: when a primary mass impacts upon the atom, the motions resulting radiate from the point of impact along the surface of the atom, wherefore many of them concenter and meet near the pole and make it the center of more intense activity than exists at the parts more distant from the pole. This effect is planly greater the greater the size of the atom. Hence it will be seen that the attraction and repulsion of atoms are *specialized* in certain ways, which condition will appear when we consider the combination of atoms in the molecule. These specializations are only effective when the distance between atoms is very small as in chemical union. Where the distances are relatively great the action of attraction and repulsion is more general, and may be regarded as acting toward the atom as a center. The attraction and repulsion of molecules are governed by the same rule, although their specialization is different in character. Atoms combine and form molecules. There is only one great mode of molecular union and that mode is the most simple that can be conceived. Atoms combine *pole to pole, flat to flat.* When many atoms are thus joined they make a row, with their poles in one line and their equatorial planes parallel. A molecule may consist of two or more atoms although the term is sometimes used in a special sense, because the gases of some bodies exist with monatomic molecules. Molecules may be formed by the union of atoms which are of the same size, or of atoms which differ in magnitude. All atoms are alike in form and mechanism, but they differ in size. Their oblate spheroidal form is like that of a double convex lens of long focus. When combined they take a position of equilibrium with reference to the forces of attraction and repulsion, which act always. Heat increases the activity between atoms and therefore forces them to greater distances from each other, while loss of heat and pressure bring the atoms into closer relationship.

Bodies of matter as we know them upon the surface of the earth exemplify three great physical conditions, namely, the solid, the liquid and the gaseous. By the application of artificial conditions of heat, cold and pressure, bodies may be investigated in all three states. Heat separates molecules for the same reason that it pushes atoms apart. The more intense the heat the more the atoms and molecules are forced asunder, until at last the single atom exists by itself and represents the molecule. Not many bodies have yet been brought to this state, but we cannot doubt that if our control of heat conditions would enable us to provide a temperature of indefinite intensity, all bodies could be resolved into single atom molecules. Mercury when gasified is monatomic. Iodine at very high temperature is 1, with lower degree of heat it is I_2. There are other examples, but the monatomic molecule owes its significance not to numerical importance but because it manifests the sequence of cause and effect, and exhibits the existence of atomic matter in its simplest form.

Most bodies have been gasified and in the majority of cases have been reduced to the state of two atom molecules.

This molecule is on general principles difficult of resolution, that is, it has a high degree of stability. This is because attraction acts with the greatest directness and most undivided simplicity no matter what the relative position of the two atoms.

Another reason is that the larger the molecule, the greater the number of its atoms the more powerful its attraction, and consequently, the action of molecule upon molecule tending to disruption is likewise intensified. This means a kind of struggle for existence among molecules. This constant tendency of atoms and molecules to attract and approach each other is also the cause of direct combination when such union is possible. When a body of oxygen gas is subjected to such action of electricity as to disrupt part of its diatomic molecules, the free atoms are attracted to and combine with some of the molecules OO, forming OOO. The superior attractive force of the latter is the means of its own destruction, hence it is technically unstable, although it evidently has more strength of union than its mere chemical phenomena indicate.

When ozone decomposes it separates into the stable molecule OO and the single atom O, which is chemically very active as all nascent atoms are. Atoms being very oblate spheroids they are very well suited to enter between other atoms, when single, but when joined together in a molecule the advantage of thinness is lost. The degree of loss depends upon the kind of molecular structure. The molecules HI, HC*l*, HSH, HF, are active chemically because they are almost as single atoms, the small atom H being unable to strongly oppose the entrance of their companion atoms between other atoms. Small atoms and molecules enter more easily than larger ones, but the larger have the advantage of greater attractive power. Water is a great solvent and the reason is plain. The water molecule is HOH, 1-16-1, the oxygen atom being in the middle with a small hydrogen atom joined to each pole. The union is very close because the special polar repulsion of the smaller atoms is less powerful than that of the larger atoms. All the smaller atoms combine closely for the same reason. The water molecule has a wedge-like action and being also small, its great solvent power is accounted for. The fact that the water molecule is a great aid and promoter of chemical action is explained in the same way, it helps to press the atoms apart so that the entrance of the disintegrating atom is allowed.

The water molecule is in certain respects unique. It alone of the smaller molecules has the structure wherein each pole of the larger atom holds closely a very small atom. HF is the smallest of the type in which one pole only of the larger atom is occupied. It has the greatest penetrative power of all molecules and with the assistance of the water molecule is able to dissolve glass. The molecule of mercury is monatomic and the great power of its attraction makes its wedge-like action very strong. Of the three states the molecules of a gas are of course the simplest. We may say that taking our atom and the mode of its combination the gas molecule is *short,* while that of the solid generally has a larger number of atoms and is *long.* OO and N_2O_5 example the two kinds of molecules.

2. TYPES OF MOLECULES.—The atom is a specialized body, a system, and to this fact we must look for the great characteristic significant mode of molecular structure and the types which result. The very oblate form of the atom is the first item in its specialization. Polarity is the second, this being double since the atom has two poles of both attraction and repulsion.

Each side of the atom is also specialized: the narrow equatorial zone of loss, the inner larger zone of attraction, of matter absorption, the special polar repulsion, all have a ruling influence upon the combining relations of the atoms. Each of these special characteristics is in itself very simple, and although a number of even simple special modes of causation give a certain degree of complexity to the problem of atomic union, yet the effect is so plainly sequent to the cause in each case that we may easily trace out the influence of each specialization. Atoms are alike in form and mechanism but vary in size from hydrogen 1 to the larger which have a magnitude of over 200. Were all atoms alike in size or if only atoms of the same size combined, there would be little chance for the special cause factors to be manifested in the results. That atoms differ only in size we may take for a starting point. Upon this we should expect to find a certain likeness of molecular types throughout. The simplest possible form of compound molecule is of course that wherein one pole only of the larger atom is occupied by a single smaller atom. HC*l*, HI, CO, NO, are gaseous examples. The second simple compound molecule has one larger atom and two smaller ones, both poles of the larger being occupied. HOH, HSH, OSO, NON, are gaseous examples. We rank next the triatomic molecule in which one smaller atom occupies the middle position between two larger ones. OCO, C*l*OC*l*, ScS, Ag, OAg, are examples. These are the three great types of the simpler compound molecules. Taking into account our atom, our molecule, and the principal mode of chemical action, that is, the entrance of atoms between other atoms, these three molecular types are what we should expect to prevail as the product of the simplest process of molcular change, of transformation. The formation of HC*l* shows that the atoms of the diatomic C*l* molecule are separated and that in the process each C*l* atom takes an atom of hydrogen. We must accept the datum that the C*l* atom has the ratio to the H atom of about 35 to 1, wherefore it is highly reasonable to suppose that the great attractive power of Cl_2 draws the hydrogen between its atoms. HI, HB*r*, HF, HOH are all products of the disruption of larger molecules by hydrogen. The use of hydrogen in reducing molecules of higher numerical atomicity to more simpler forms depends upon the mere separative effects of the hydrogen, when it enters between the larger atoms. Compounds of hydrogen are not formed during this process because the range of hydrogen affinities are low in the scale, the extreme limit under the most favorable heat conditions being HI, which is very easily decomposed. Oxygen having 16 times the attractive power of hydrogen its range of affinities extends much higher, even to the top of the scale. All the way up the scale oxygen forms the short compound molecules by cutting off atoms from the larger molecules. An atom of the infusible carbon being separated from its molecule, forms with oxygen atoms the gases OCO and CO. Sulphur burns in oxygen and forms OSO. Zinc burns and forms ZO. Sulphur and chorine act in the same way as oxygen, and form the same types of molecules. The mode of chemical action is so universal and such a vast number of examples are available, that it is unnecessary to particularize to the student of chemistry. Our oblate spheroidal atom and their mode of association specially and inevitably induce the great process of chemical action described. The three great types of short compound molecules are the direct product. We will proceed to notice some important and significant facts relating to these three types of molecule. Hydrogen fluoride gas been found to have the molecule H_2F_2 at about 30 degrees, while at higher temperature it is HF. Compare HF with HOH; both poles of O are occupied by an H atom whereas only one pole of F, the larger atom in HF, is occupied. Our atom being supposed it would be strange if HF did not polymerize at a lower temperature, and it would be equally a sound inference that HOH is chemically neutral because both poles are occupied and guarded by closely joined atoms. The type HF is greatly prevalent, and it cannot be doubted that the halides have polymeric molecules when they exist in the liquid and solid states. The type HF, if we suppose our atom, recombines as a natural and logical consequence of its unsatisfied polarity. It does not necessarily combine with itself but the unsatisfied pole may take another atom or another a different molecule.

The two gases $\mathrm{HC}l$ and NII_3 combine directly and form the solid sal-ammoniac. The two kinds of molecules separate when heated and recombine when cooled in perfect analogy to the phenomena of HF. CO decomposes, OO takes one of its atoms and forms OCO. We quote from Mixter, page 244: "Nitric oxide is distinguished "from all other colorless gases by forming red fumes of "nitrogen tetroxide when mixed with oxygen or air." The compound radical cyanogen is a good example of the tendency of the compound diatomic molecules to recombine. Both of the great types of triatomic molecules represent the addition of a single atom to the compound diatomic molecule, although the entire process generally takes place at once and the molecules of the first or second triatomic type emerge directly from the chemical action. Tin oxide $\mathrm{S}n\mathrm{O}$ burns to $\mathrm{S}n\mathrm{O}_2$, but the the latter is also produced directly by heating tin in air. This is only an example of a quite general action. The first type of compound triatomic molecule consists of two smaller atoms joined to a larger atom which is in the middle and thus has both poles occupied. This type is very numerous and ranges from the water molecule HOH up to OUO. The magnitudes are 1-16 and 16-239, but proportionally the magnitude relations are almost the same in both cases.

This type is preeminently the symmetrical type of all. The larger central atom with each pole held and guarded by a smaller atom, should be a strong form and the facts show all up through the scale in a multitude of cases that it is so. It has the kind of structure that gives what may be termed completeness, finish, although it still has poles as all molecules have, but ,however, its poles are both smaller atoms and its attraction is more evenly distributed about the whole molecule. Having less tendency to recombine it contrasts with the compound diatomic molecule which has one larger unoccupied pole. Compared with the third type in which the middle atom is the smaller, the symmetrical type is permanent and prevalent. The third type does not compare in numerical or other importance with the other two types. Having the two larger atoms joined to the poles of the smaller the structure is unsymmetrical, and in general easily disintegrated by heat or chemical action. Its atomatic arrangement invites the chemical attack of other atoms and molecules, whereas the type which has the larger atom in the middle is itself better defended and is rather suited to enter between other atoms and molecules. The third type has, however, some examples of rather stable molecules of which OCO is perhaps the most striking. Our next section will account for these facts under the principle of affinity.

3. CHEMICAL AFFINITY.—This principle depends upon the existence of special zones of attraction and repulsion upon the surface of the atom.

There are three and only three elements in true affinity:

1. The equatorial zone of repulsion which is a narrow region about the equator.

2. The zones of attraction which are inside the equatorial zones upon each side of the atom and have each a pole of the atom for a center.

3. The special polar repulsion which is least in case of the smallest atom and augments gradually to the largest, being proportional to atomic magnitude. We must

not confound affinity with the fact that *attraction* varies according to the magnitude of atoms and molecules. Attraction is simple, direct, but affinity is more special, depends more upon intimate relations, upon fitness atom to atom. Attraction acts in a general way at greater or less distances, its intensity being ruled by the law of the inverse squares. Affinity is only effective in the relations of atoms when at or very near combining distance and position. The test of affinity is stability, not the power of chemical action. The latter is really evidence that affinity is overcome, that it lacks the ability to withstand chemical attack. The three great chemical principles are attraction, repulsion, and affinity. The third element of affinity, that is, the special polar repulsion being more powerful with the larger atoms, we must expect to find the evidence of its existence as we follow the compounds of any particular element, say hydrogen or oxygen, up the magnitude scale. Hydrogen is the lowest on the scale, hence the effect of the special polar repulsion reaches its culmination, at a lower point of the ascending atomic scale than is the case with any other atom. This point is far below the top of the scale, its extreme limit being the molecule HI, W*t* 1-127. Hydrogen iodide is very unstable. Down the scale is HSH W*t* 1-32-1. This molecule belongs to the symmetrical type and to this fact it owes what stability it has; but the difference is too great and the fact is exhibited by its chemical power. Compare HSH and OSO. Fitness in the latter is far better exemplified. When the atoms of a molecule are too nearly one size the smaller does not wholly lie inside the equatorial zone of the larger atom, and therefore avoids only part of the special repulsion due in that zone. Compare ONO and OCO, the latter is more stable. CO is more stable than NO or CN. HOH has a high degree of stability, but this is partly due to the fact that the water molecule belongs to the first type of simple compound molecules. Contrast with carbon disulphide SCS. The affinity relations account for the great difference in their stability.

While hydrogen combines with other atoms only to a limit, part way up the scale, oxygen combines all the way to the highest atomic magnitude. The first atom above oxygen, florine, is the only exception. Their affinity difference is very small. Magnesia W 24 forms a stable molecule with oxygen. Alumina and silica exhibit perhaps the highest point of oxygen affinity. Calcium and oxygen form a very stable simple molecule. The simple oxide of potassium is of the wrong type, that is, the third type, it is KOK; but even then it endures a white heat. The group Mn55, Fe56, Ni58, Co59 vary only four hydrogen magnitudes throughout the series. Their oxides are remarkably analagous. By ascending the scale about one hundred and fifty hydrogen magnitudes or nearly four times the atomic weights of the group noted, we arrive at a point in the scale where the effect of the special polar repulsion becomes very evident in the instability of the oxides. Of course this is a matter of degree only, but the comparison between a group comprising mercury, lead, bismuth, gold, platinum, and thallium, all being near 200 in atomic weight, and the group mentioned above, whose atomic weights are situated about 55 on the scale, seems to exhibit a sharp advance in the force of polar repulsion.

The attraction between an atom of lead and an atom of oxygen is much more powerful than that between an atom of manganese and an atom of oxygen. The numbers are Pb 207, O16, Mn55, O16. Not only are the simple oxides of manganese and the others of its group, far more stable under the disintegrating action of heat than the similar oxides of the group whose atomic weights are much higher up the scale, but the oxides Mn_2O_3, Fe_2O_3, Co_2O_3, Ni_2O_3 exist with a high degree of permanence. This group is of course an arbitrary selection, but as we go down the scale contrast with the high scale oxides is perhaps more striking. Cr atomic weight 52½ forms Cr_2O_3, the crystals of which are sufficiently hard as to scratch glass and steel, and which requires the flame of the compound blowpipe for its fusion. Titanium affords the same kind of testimony. When we go to the bottom of the scale we shall find evidence of the great importance of the special polar repulsion, only in another way, that is, by its weakness or comparative absence. Before entering the discussion of affinity from this standpoint it is best to form an understanding concerning the question of valence.

4. VALENCE.—We quote Mixter, page 152: "Sul-"phur Tetrachloride SCl_4 is formed when chlorine is "passed into the dichloride cooled to -22 degrees. The "liquid obtained evolves chlorine as soon as the tempera-"ture rises." The dichloride is SCl_2 and chlorine being Cl_2 the formation of SCl_4 seems to be a case of simple, direct combination. The atom S appears then to be able to hold four chlorine atoms at —22 degrees, but not at higher temperatures. Our bipolar atom and molecule accounts for the entire action in the most simple and clear manner.

The varying power of repulsion due to the different degrees of heat activity, of motion intensity, between the atoms and the consequent variation in the capacity to combine, are plain, simple facts of cause and effect.

We have already noted the change of HF to HFHF through diminished heat repulsion. The water molecule HOH does not combine with itself as does HF. A single oxygen atom is added in the molecule of hydrogen dioxide HOHO, but the extra atom is very easily dislodged. The carbon atom is able to hold four hydrogen atoms. Methane burns with explosive violence. When an alloy of silicon and magnesium is treated with hydrochloric acid SiH_4 and hydrogen are evolved and the mixed gas ignites spontaneously on escaping into air and burns with the formation of a cloud of silica. Contrast SiH_4 with SiO_2.

Our oblate spheroidal atom having two poles only, can *directly* combine with *two other atoms only,* but it may have joined to each or either of its poles an *atomic group.* Since atoms combine pole to pole each group of atoms or molecules has two poles, in other words, polarity is never eliminated by combination. Polarity may be reduced as when smaller atoms are joined to the poles of larger atoms. The great diatomic type of compound molecules exhibit the occupation of one pole, while the first great triatomic type shows the occupation and reduction of both poles of the larger atom. The latter structure makes for stability and also by the reduction of *both* poles prevents the formation of polymers, and lessens the tendency to recombination, wherefore the prevalence of this, the symmetrical molecule, from top to bottom of the atomic scale.

In the molecule H_2CH_2 methane, a whole molecule of hydrogen, is joined to each pole of the carbon atom. One atom only of each H molecule can be in *direct* relation to each carbon pole, wherefore the power of attraction tending to disintegration and chemical action between the components of this molecule H_2CH_2 and another molecule as OO, is greater in proportion to the holding force than would be the case if only a single atom were joined to each pole of the middle atom. The phenomena of SiH_4 is due to the same cause, and the principle is general throughout the facts of molcular structure. The great variety of compound molecules known to science is made possible by the control of *conditions*, including the selection of material. Atoms and molecules have bipolar attractive functions, hence they *always* tend to further combinations which only preventing force conditions can stop. Also atoms and molecules *always* tend to act upon each other, and put their respective molecular bonds of union to the test. Atoms and molecules mutually attract and will enter between each other's atoms if possible. With reference to valency atoms tend to form the largest groups possible with the conditions present. This is not a question of stability but of polar holding power, of the *greatest* number of atoms which a given atom can attract and attach to its poles. Stability on the other hand is a question of arrangement according to fitness or affinity, acting in conjunction with attractive power. Contrast $OSiO$ with SiF_4 and $SiCl_4$, of the latter one is a fuming gas and the other a fuming liquid. The combination of HCl and NH_3 has been noted. Compare with the union of $SnCl_4$, or Cl_2, Sn, Cl_2 and NH_3. Each pole of the first molecule takes a molecule of NH_3, forming $2NH_3\ Sn\ Cl_4$. As before noted $OCrOCrO$ is so hard as to scratch glass or steel, but the compound Cr_6 is a fuming liquid. One is a good example of stable arrangement, the other a striking instance of extreme polar union. All through the atomic scale we may find exampled the tendency of excessive unstable polar union contrasted with stable molecular arrangement. Every atom, *all* atoms, tend at *all* times to draw to their poles and attach the greatest number of atoms and atomic groups possible. The cause factors, polar power, conditions of heat, etc., determine the outcome. Atoms of the same size follow the same law, they form the largest molecules possible but they have not the advantage of affinity, which exists in the relations of atoms of different magnitudes. The latter condition is very important to stable formation. The tendency to the highest degree of polar union and the arrangement which makes for stability, are *both* concerned in the explanation of valency.

5. STABILITY.—The zone of equatorial repulsion is common to all atoms, and from the top to the bottom of the scale does not vary to any great degree, but the special polar repulsion is more intense the greater the size of atoms. Near the top of the scale, as we have noted, the effect is very apparent, but at the bottom of the scale we may assume that it is reduced to almost the vanishing point. The diameters, or atoms are not proportional to their atomic weights, but to the square roots of their atomic weights. Thus the hydrogen atom and the oxygen atom are as one to four in diameter. When an H atom is joined to the poles of an oxygen, a nitrogen, or a carbon atom, the former extends more nearly to the equatorial zone than the numbers 16, 14 and 12, respectively, would

at first thought indicate. Of these three atoms carbon has the least special polar repulsion, and the hydrogen atom has less than any other. Again, the relation 1 to 12 is better than 1 to 14 or 1 to 16 with reference to affinity. These differences of affinity conditions are exhibited by the molecules CH_4 NH_3 and OH_2. Ammonium NH_4 does not exist in the free state; the affinity relations are inferior to those which make CH_4 possible, but however, aided by other atomic attractions, NH_4 can exist in compounds. Water HOH cannot form the molecule HOH HOH, but C and H can and do, form this type and its polymers, up to a high degree of numerical complexity. No larger atom than carbon is able with hydrogen to form this type, and the polar affinities of our atom explain clearly and simply the cause conditions. The carbon atom cannot hold three H atoms upon each pole. Note the marsh gas, series H_2CH_2, $H_2CH_2CH_2$, $H_2CH_2CH_2CH_2$, or CH_4, C_2H_6, C_3H_8, etc., etc. Only the ends of the molecules hold two hydrogen atoms to the carbon pole. The interior hydrogen bonds consist of two, not more atoms. The carbo-hydrates and the many other types and series of carbon compounds exhibit the agency of the hydrogen atom and molecule as the *bond,* which, by alternation with other atoms and atomic groups, makes possible the variety and great numerical complexity which characterize those compounds. The great principle of arrangement whereby larger and smaller atoms alternate in molecular structure, is the direct sequence of our bipolar atomic attraction and the affinities which depend upon magnitude differences.

Not only the carbon compounds, but cyanogen, the halides, such compounds as CaO, Pts, etc., and another great and prevalent type exampled by Fc_2O_3, Co_2O_3, etc., exhibit the alternate mode of arrangement. Compare OCr OCrO with CrO_3 and CrF_6, and contrast the relative stability. They example the stability of the alternate arrangement upon the one hand, and upon the other the tendency of an atom to hold to its poles the greatest possible number of atoms allowed by the conditions of heat, affinity relations, etc. All through the great list of compounds is manifested the great importance to stability which belongs to this great mode of alternate structure. All long molecules exhibit it either in simple or modified form. The more different kinds of atoms joined in a molecule, of course, the more complex are the relations, hence a discussion of these cannot be had in our limited space. Our bipolar atom and mode of molecular structure perfectly solve the questions of stability and valence.

III. GENERAL DISCUSSION

1. CRYSTALIZATION.—The mutual attraction of molecules tends to test their stability and its failure means the chemical action which includes disintegration. When stability *holds* the molecules may condense or aggregate, and form a solid or liquid body. The structure of *molecules* depends upon a kind of relative arrangement which the shape, size, and force characteristics of atoms rules, and the structure of a *crystal* depends upon the shape, size and force characteristics of molecules All molecules as well as all atoms have polarity. Some molecules are *short,* for example HOH, and many others are *long,* and the modes of their association when forming crystals varies accordingly. The crystaline structure denotes regularity of arrangement, hence the fact that it often conduces to greater stability and density is plainly accounted for. The organization of crystals is not of a high order, and, in importance does not compare with that of molecules. Crystals are of more or less gradual growth since when solidification is very rapid the molecules do not have time for arrangement, but associate in a helter-skelter manner.

2. HEAT AND LIGHT.—All bodies known to our experience are composed of atoms. Our home, the Earth, is a branch of the sun, a product of an evolution process which has taken vast cycles of time, and which has

brought about that high degree of atomic condensation which characterizes the bodies present to our experience. The organs of sense, for example the eye, are atomic bodies, are made of atoms. The eye testifies wonderfully to the existence of another order of physical being, which is concerned in bringing force action from distant objects and impressing it upon the visual nerve. Of the mentality of sight we offer no account, but the eye is a physical organ, a mechanical arrangement, which has been developed in perfect adjustment to the force medium whose existence preceded itself. This medium exists between the atoms and molecules of all bodies. To this existence science has given the name *"The luminaferous ether."*

We propose that it is a distinct order of matter and motions, absolutely simple and definite in character, the greatest physical fact in the universe and the basis of all other more complex physical being. Atoms, worlds and suns not only owe their origin in the most minute detail to the simple basic order, but also each instant of existence. A clear understanding of the fundamental character of the primary order of matter and motions, its relations to the other orders, the organized orders of matter and motions, is necessary to an adequate conception of its transcendent importance. It is customary to say that the *ether,* the primary order of matter and motions, exists between and surrounds the atoms of all bodies, but while this is exact so far as it goes, it states only the part of the fact which is the least significant. The point of view is at fault. To say that atoms exist in and by potency of the primary order of matter and motions, which exists throughout space is a definition from the right standpoint. With reference to sight the atoms of the object and the atoms of the eye have the same relation to the primary masses and motions, the same intense actions and reactions which belong to an order of motions so high, that their degree can only be expressed in terms of velocity which belong to the process by which light and electricity are transmitted. Motions radiate from all atoms at all times, but a certain quantity and intensity is necessary to produce the visual effect of white light. Color belongs to the *mind* and the several kinds of color represent divisions or graduations upon the intensity scale. Beyond the ends of the color scale are motions which convey no sense of color to the mind. The motions of light and heat which radiate from all atomic bodies represent different degrees of motion velocities, which the reaction of the collisions that take place between and upon the atoms differentiates. All these radiations convey heat, hence the latter term includes *all*, and is therefore a general term while light includes only a certain section of the scale and has therefore a special limited reference.

3. Heat in Chemical Action.—The atoms of molecules exist under the influence of mutual attraction, and this attraction is counterbalanced by repulsion, by the active motions of the primary matter between the atoms. The molecules of solid liquid and gaseous bodies also attract each other, and the activity of the primary matter between opposes, and sustains a state of equipoise between attraction and repulsion. *Pressure* and attraction act together, hence repulsion must have sufficient power to balance the force of both. Increase in the activity of the motions which cause repulsion causes expansion, and a diminution of activity causes the contraction of bodies. Wherefore when a gas changes to a liquid or solid, the process includes an issue or withdrawal of heat. The heat issue of condensation which includes also the shrinkage of solid and liquid bodies, does not belong to chemical action. The formation of HCl is a case of chemical action where the product is gaseous and has the same volume as the two gases which are its combining factors, hence the heat that appears may be regarded as coming wholly from the chemical action. When a gas condenses, its latent heat becomes sensible, because it no longer has the *work* to do of holding the gas molecules apart, at the

relatively great distances which characterize the gaseous state. The Cl and H molecules are diatomic and when the H molecule enters between the two atoms of the Cl molecules and forces them asunder, the motion activity which held the Cl atoms apart has no longer that *work* to do and therefore issues as sensible heat. Sulphur vapor acts chemically with glowing charcoal forming S2C or SCS. Heat is absorbed in this chemical action. The molecule SCS has a loose structure, the principal atoms are held rather far apart, but *not disrupted,* hence the conditions *within* the molecule are the reverse of those which in the condensing process cause the issue of heat. When HH and OO act chemically to form water the entire repulsion activity performing work in OO, latent from a heat standpoint, is liberated. There is, however, a second source of heat in this case because one volume of O plus 2 volumes of H condense to 2 volumes of HO vapor. Latent heat is heat at *work* and when from any cause the task is removed the heat appears. Atoms enter between other atoms, and if disruption occurs the motion activities are liberated as the heat of chemical action. Heat from this source and the heat of condensation often appear together and their addition forms a total as exampled in the formation of water. From the latent heat of the gas molecules OO and HH to the state of water as ice are several steps of latent heat conditions, and if we could realize for use *all* the work at once, it would be a great total.

4. THE TIME PERIODS OF SOLAR EVOLUTION.—Our system being assumed, the development of gravitation by gradual progress from small beginnings, the processes by which atoms or atomic groups concentered to a globular nebula, the rotary process began and grew to the potency required for the formation of a planetary ring, the creation of each successive ring, the lateral concentration of the ring material to secondary nebulae, the evolution of those secondary nebulae into planets and then moons, and the progress of the planets including the

earth to their present state, have all consumed far vaster cycles of duration than the calculations from ordinary standpoints have brought to their estimation. Radiation has existed from the time when a small group of atoms made up all that was of the future solar system. The radial inflow also then began, and both radial outflow and inflow grew in quantity as atoms and atomic group were added.

The process goes on at present as throughout the past, and each meteor adds its mite to the power of radiation and gravitation. Meteoric addition and the gradual shrinkage of the nebula and now of the sun account for a great supply of energy for radiation, but there is another, an incomparably *vaster source,* that is the energy which the inflow of primary matter brings. This inflow is the cause of gravitation and comes from surrounding space in all directions. But a relatively minute portion of the inflow is expended upon the planets in retaining them in their orbits, hence the vaster ratio goes to the sun and its energy is returned by radiation to the deeps of space. All other sources of radiation sink almost to the vanishing point in comparison with this mighty inflow of energy. All methods of calculation hitherto employed, while taking the full amount of radiation, have included upon the other side of the account only the insignificant factors of the energy supply. The effect is of course to underestimate immensely the length of all periods required for development processes.

The geological records demand in their account the vaster periods, but have been denied by the cosmogonists, who have left out the chief multiplying factor in their estimate.

5. THE MECHANICS OF SOLAR RADIATION AND GRAVITATION.—This double process denotes the existence of two forces acting by means of motions in opposite directions through the same space. This has the appearance of a paradox in mechanics, but is in reality a very simple process. The motions which radiate from the sun

rank with the most intense, the highest order of motion velocities in the universe. The enormous number of atoms which the solar body comprises, cause the process of action and reaction which differentiates the motions of the primary masses to multiply to a very high degree, and produce motions of immense velocities. The particles which acquire these intense motions have also by the process of rapid and successive division become so minute, as to be described as infinitesimal.

These particles escape into surrounding space, and since the energies of motions are proportional to the velocity squares they carry away, relative to their mass, a high ratio of energy. At the same time proceeds the relatively slow inflow of primary matter which furnishes the force that causes bodies to gravitate. Each atom of the sun contributes its share to the great double process of outgoing and ingoing radial motions. The same is the case with the planets, with *all* bodies which are made up of atomic unit systems. Differentiation of motions is proportional to the greatness of atomic assemblages and radiation and gravitation vary accordingly. The stars, including our sun, cannot become cold and lightless. The energy they emit is not derived from themselves but from that great primary order of matter and motions which is the basis of all bodies and energies. Neither is one iota of the vast energies which the stars radiate into space lost, but is returned to that great store of energy, the simple motions of the fundamental order.

6. THE DATA OF MOTION VELOCITIES.—Perhaps no other facts show more plainly how inadequate is ordinary experience to give us a true knowledge of existence in its reality, than do those which relate to the different orders of motion velocities. Compared to the motions which surround us in our existence upon the surface of the Earth, the orbital velocities of the planetary bodies are enormous. High as the order to which these motions belong, facts prove the existence of another order so high, that its velocities compare with the orbital motions as

the latter compare with the slow movements of our ordinary experience. Light and electricity progress through space with these high velocities.

These velocities of straightforward translation are however only the *easy* part of the problem. The road which electricity travels goes through so-called conductors which are among the most dense bodies known to our experience. We cannot suppose that the motions which transmit the electrical effect are simple and straight throughout the conducting body, but must consider that action and reaction with themselves and with the atoms of the conductor, occur all along the way. The actual, final motions then must plainly have far greater velocities than the progress along the road of the known electrical effect manifests. All the actions and reactions take time, hence we have evidence here by inference of a yet higher order of motions than the progress of light and electricity directly evidence.

The truth is that motions are purely and strictly relative, and our experience and conceptions have nothing whatever to do with the solution of the problem which the facts of their existence present. The facts and the mechanical and mathematical relations are the way to the truth.

7. DIVISIBILITY.—Matter, like space, admits of successive division to infinity. Any finite rate of division acting through any finite time cannot diminish the divisibility of any finite body of matter. The inconceivably high order of the activity, the motions and collisions, which characterize the primary order of matter and motions, acting through star and galaxy building cycles, approach no nearer the *end* of the capacity of the primary bodies for division than when those cycles began. This condition favors gradual evolution processes. The different order of bodies compare with the reference to difference of magnitude, as the different orders of motions compare in respect to higher and lower degrees of velocity. As a single atom is related to a star in point of size, likewise

is a particle of the primary order of matter related to an atom. Direct knowledge has nothing to do with such facts, it is wholly inadequate and gives no clue. Yet we have only to reason from the wonderful facts connected with the sense of sight to understand that there must be incomparably more subtle and more powerful orders of existence than the bodies and motion known to our direct experience. The velocities of electricity and light afford the clue which we must follow to an understanding of the actual state of these existences.